Chapter 2.12
Semantic Approach to Knowledge Representation and Processing

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ABSTRACT

In this chapter, several knowledge representation and processing techniques based on a symbolic and semantic approach are briefly described. The majority of present-day techniques, like the relational database model or OWL (Web Ontology Language), is based on the symbolic approach and supports the representation and processing of semantically related knowledge. Although these two techniques have found many successful applications, there are certain limitations in their wider use, stemming from the use of naming in explicit description of the meaning of the represented knowledge. To overcome these limitations, the authors propose a technique based on the semantic approach, Hierarchical Semantic Form (HSF), that uses semantic contexts to implicitly define the meaning. This chapter first provides concise information about the two most popular techniques and their limitations, and then proposes a new technique based on semantic approach, which facilitates a large scale processing of semantic knowledge represented in natural language documents.

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INTRODUCTION

Seven years have passed since the idea of Semantic Web was introduced. In the meantime, many ontology and schema languages have been proposed and many Semantic Web and other processing techniques have been introduced, which provide

a functionality needed for semantic knowledge representation and processing. Despite all that, a very moderate progress has been recorded in the past period regarding the number of practical applications of these techniques. Truly, these techniques provide the required capacity, but the development of Semantic Web applications is still very expensive, because skilful ontology designers are required to describe the domain and programmers are needed to interpret these descriptions and implement the application at hand.

Although the existing semantic knowledge representation techniques enable the representation of semantic knowledge, they are, in their essence, based on the symbolic approach to knowledge representation. The symbolic approach was introduced with the advent of the first high level programming languages, where symbols (variables), described by their names and values, were used in various calculations to produce the desired results. To facilitate the representation of semantically related information, symbols became more complex, enabling the representation of structure either internally (tables-fields, classes-attributes) or externally (using different relationships). However, the essence of the symbolic approach is preserved, because the names (of tables, fields, relationships, classes, objects, attributes, etc.) are used to define their meaning. Due to the increased complexity, the role of a programmer in symbolic programming has been twofold: the role of an ontology designer responsible for describing the application domain and the role of an application programmer in charge for the processing of the represented knowledge.

Computers are not able to automatically provide domain descriptions, or to interpret automatically the represented knowledge, so the role of highly specialized human experts that will perform these jobs in developing semantic knowledge processing applications is inevitable. As a consequence, the development of such applications is more expensive than in case of symbolic applications, which prevents their use on a large scale. Another consequence of the application of the symbolic approach to semantic knowledge representation is that representational ability of the corresponding knowledge representation techniques is both defined and limited by their design, i.e., these techniques are domain dependent. Each extension of the application domain or merging the knowledge from different domains or even the same domain requires substantial and non-trivial redesigning of the existing ontologies.

Since the symbolic approach to semantic knowledge representation creates the problems mentioned above, the question is - what would be the requirements for the pure semantic approach to knowledge representation that would overcome the spotted problems? The minimum requirements would include the ability to represent the concepts and relationship between these concepts. In the framework of natural language texts, concepts at the lowest level of hierarchy would be letters, at one level higher –syllables, then words, phrases, sentences, paragraphs etc. The relationships between letters are described by the contexts representing syllables, the relationships between syllables – by the context defined by words and so on. The basic semantic knowledge requirements could be defined in terms of two principles: a principle of unique representation and a principle of locality. The principle of unique representation states that all concepts at different levels of hierarchy must be uniquely represented within all contexts they may appear in. The principle of locality states that contexts at different levels of hierarchy are composed of the concepts of the corresponding complexity. The letters are of the atomic nature, while other concepts have a complex structure comprised of sequences of concepts with lower complexity, i.e., syllables are composed of letters, words are composed of syllables, phrases are composed of words etc.

The semantic knowledge representation technique presented in this paper enables automatic translation of texts into a structured form and vice versa, with no loss of information, and with auto-